MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EMG4076 – ELECTROMAGNETIC INTERFERENCE

(TE, RE)

16 FEBRUARY 2023
9.00 A.M. – 11.00 A.M.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 5 pages including cover page with 4 Questions only.

2. Attempt all **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer Booklet provided.

Question 1

(a) Consider three parallel wires, two are signal leads (lead-1 and lead-2) and the third is a common signal-return lead (lead-G). The circuit of **Figure Q1** represents the inductive coupling between the circuits.

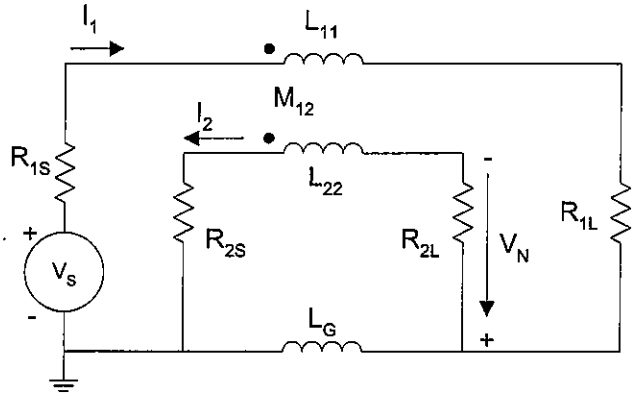

Figure Q1

(i) Show that the noise voltage V_N can be expressed as

$$V_N = K\frac{j\omega}{(j\omega+s_a)(j\omega+s_b)}V_S$$

where K, s_a and s_b are unknowns to be determined.

[12 marks]

(ii) Derive an approximate expression for V_N at low frequency, mid-frequency and high frequency.

[9 marks]

(iii) Draw the equivalent circuit if lead-1 is shielded in order to reduce magnetic coupling.

[4 marks]

Continued...

Question 2

(a) With the aid of diagrams, explain the differences between 'multipoint ground' and 'hybrid ground.'

[10 marks]

(b) Layout design requires knowledge of how each current flows and returns to its source.

(i) Explain how micro strip can reduce the electromagnetic interference (EMI) for a double layer printed circuit board (PCB).

[5 marks]

(ii) State an alternative way to reduce EMI for a single layer PCB.

[2 marks]

(c) Consider a signal source that is connected to the load resistor using a pair of wires as in **Figure Q2**. The mutual inductance (M) between the two wires increases when they are placed closer together. A common ground-wire exists in the electronic system.

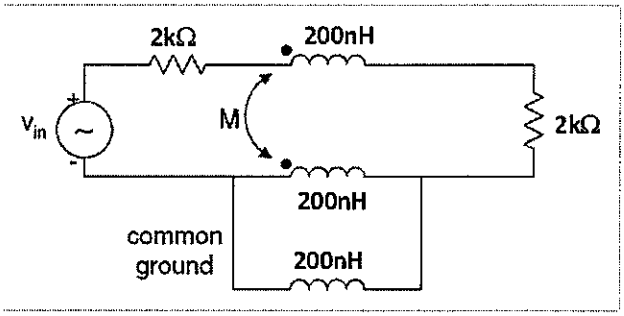

Figure Q2

(i) Calculate the percentage of return current diverted through the common ground for values of mutual inductance, M=190 nH, M=100 nH and $M = 0$.

[6 marks]

(ii) From your answer in part (i), briefly explain which value of mutual inductance, M that will greatly reduce the electromagnetic interference in the circuit.

[2 marks]

Continued...

Question 3

(a) Sketch the graph of wave impedance Z_w versus electrical length (0.01λ - 10λ) for electric and magnetic sources.

[6 marks]

(b) Consider two 1-meter parallel wires separated at 0.5mm carrying equal and opposite current of 200mA at 100MHz. An antenna (oriented parallel to the wire) is used to measure the radiated emission at a distance 3m away from the wires. If the antenna factor is 20dB,

(i) Determine whether the receiver antenna is in the near-field or far-field region.

[2 marks]

(ii) Assuming negligible loss for the cable connecting the antenna to the spectrum analyzer, determine the voltage measured by a spectrum analyzer in dBμV.

[5 marks]

[Hint: Electric field magnitude at far field of a loop antenna, $E_{loop} = \eta \frac{k^2 I_0 A}{4\pi r}$ and antenna Factor (dB) = incident electric field (dBμV/m) - received voltage (dBμV)]

(c) A panel, 12 cm wide and 36 cm high, is attached to a cabinet by 24 equally spaced screws around its perimeter, including one screw at each corner. The equipment in the cabinet generates a 150 MHz signal. Assume all the phases of the signals from all slots are equal and neglect any interference to aperture currents from adjacent slots,

(i) Calculate the attenuation of this signal when it passes through the resulting slots and reach the receiving antenna 30 m away from the shield.

[5 marks]

[Hint: Attenuation A due to a slot of length l at a distance r from the slot is approximately $A = 73 - 132.45\frac{l}{\lambda} + 20\log\frac{r}{\lambda}$ dB where λ is the wavelength of the signal.]

(ii) If 8 equally spaced screws are used, including one at each corner, how much is the attenuation when the signal pass through the resulting slots to reach the receiving antenna 30 m away from the shield?

[4 marks]

(iii) From your answer in part (i) and (ii), which case is more effective in reducing the electromagnetic interference (EMI). Explain your answer.

[3 marks]

Continued...

Question 4

(a) Explain the term electromagnetic compatibility (EMC) and state one of the EMC standards bodies for each of the following: International, European and United States.

[2+3 marks]

(b) An antenna is connected to a spectrum analyzer using a 10 meters coaxial cable to measure the radiated emission from equipment under test (EUT). The distance between the EUT and the antenna is 3 meters. At 200MHz, the loss of the coaxial cable is 1.5 dB per meter and the antenna factor is 4dB. If the reading on the spectrum analyzer is 20dBμV,

(i) Compute the electric field strength at the antenna in dBμV/m.

[3 marks]

(ii) The EN55022 radiated emission limits are given in **Table Q4**. Compute the Class B limits in dBμV/m at 3 meter distance.

[4 marks]

Table Q4

Frequency Range (MHz)	Class A Limit at 10m (μV/m)	Class B Limit at 10m (μV/m)
30 to 230	100	32
230 to 1000	224	71

(iii) Evaluate whether the product pass or fail the EN55022 Class B radiated emission test.

[2 marks]

(c) Sketch the setup of an automated system for radiated emission measurements. Describe the measurement procedure.

[11 marks]

End of Paper